Building Scale Models of D.C. Memorials

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Abstract This article describes an activity completed by middle school math students prior to the class trip to Washington, D.C. The activity could be completed by students in grades 6-10 working with ratios, proportional reasoning, and scale models. This activity combines mathematical content with research and historical facts from our nation's capital, as well as real-life experiences on information gathering and messy data.

Ratio and proportional reasoning are major concepts in middle school mathematics. In the Common Core State Standards for School Mathematics (2010), Ratios and Proportional Relationships are one of the conceptual categories for grades 6 and 7. One of the critical areas of focus for 6th grade is "*connecting ratio and rate to whole number multiplication and division and using concepts of ratio and rate to solve problems*" (CCSSI, 2010, p. 39). In 7th grade, one of the critical areas is "*developing understanding of and applying proportional relationships*" (p. 46) and Geometry Standard 7.G.1 is to "*solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale*" (p. 49). Further, in the *Principles and Standards for School Mathematics* (NCTM, 2000), one of the expectations for students in grades 6-8 is to "*understand and use ratios and proportions to represent quantitative relationships*" (p. 214).

In this activity, students work as engineers to find measurements and build scale models of the monuments, memorials, and museums in Washington, D.C. In our school, the 8th grade class takes a trip to visit these memorials in person. This activity helps familiarize the students with the museums, memorials, and monuments they will see in and around the National Mall. Through the activity, 7th grade students practice problem-solving skills as they encounter difficulties and engage in real-world skills as they negotiate these challenges and build a physical scale model of one museum or memorial.

When students are faced with such an open-ended scale model task, they will grapple with concepts of proportional reasoning. They will need to make mathematical decisions related to determining an appropriate scale factor, converting measurements, and calculating measurements. In doing so, they will engage in the Standards for Mathematical Practice, including "*make sense of problems and persevere in solving them*" and "*model with mathematics*" (CCSSI, 2010, p. 7, 8).

Activity Launch

The students were introduced to this activity with a discussion about their knowledge of the monuments and their sizes. Students had previously learned how to write ratios and proportions, solve proportions, and calculate scale factors. This lesson is a cumulative application of those skills.

Students were presented with a list of monuments, memorials, and museums in Washington, D.C. (see Table 1), and each team of 2 selected a building to represent. The students used brochures, books, and computers to research their chosen structure. Students found pictures in these brochures or online that they used as references when building their models. Often, this meant that they were creating a scale model from a scale drawing, while also considering the measurements of the actual structure, which added to the complexity of the task.

Table 1

List of Washington D.C. Buildings, Memorials, & Monuments

Washington Monument	Jefferson Memorial	Lincoln Memorial
Pentagon	Vietnam Wall and Statue	Korean War Memorial
World War II Memorial	Iwo Jima Memorial	US History Museum
Arlington Cemetery	Museum of Natural History	National Gallery of Art
Hirshorn Museum of Art and Sculpture Gallery	National Museum of the American Indian	Martin Luther King, Jr. Memorial
Union Station	Smithsonian Castle	Supreme Court
National Archives	Air and Space Museum	Franklin D. Roosevelt Memorial
The White House	Capitol Building	

Project Guidelines

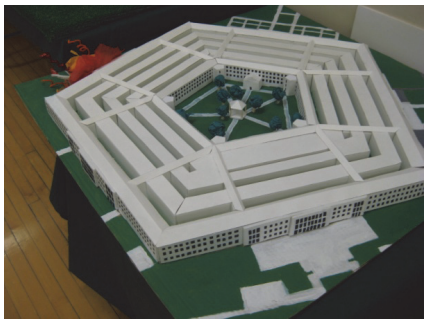
The project consisted of three components: a plan, a scale model, and a fact sheet. Students were required to create a plan for constructing their scale model and submit it to the teacher along with a sketch prior to construction. A due date for the plan was set for two weeks prior to the due date of the final project. After receiving feedback, the students were to build a freestanding structure. The fact sheet had to include a photo of the structure, three facts, and three interesting items for those who would be visiting the structure.

Several guidelines were provided for the project (see Attachment A). The models had to visually look like the actual structure, including color and landscaping, as well as be to scale. The models also had to be freestanding and able to stand on a table. The models had to be larger than one cubic foot, but smaller than 24 inches by 36 inches by 36 inches.

Problem-Solving Challenges

Students encountered difficulty when trying to find the actual dimensions of certain buildings or determining how to represent oddly-shaped structures. This led to some creative problem-solving strategies and the use of alternative materials. Students also had to make difficult decisions about what features to include and how to represent them.

Due to National Security restrictions, the dimensions of some structures, such as The White House and Capitol Building, are not available online. In some cases, the students were able to find information about some buildings by calling building employees to obtain dimensions. In other cases, building employees were not able to provide the information, so the students worked with other teams in the class. They used satellite images and panorama photos to view their structure in relation to nearby structures. They determined the actual measurements of a nearby building or structure from another team in the class. The students then used scale factors and proportional reasoning to determine the dimensions of their structure given the dimensions of the other structure.



Occasionally, students were only able to find one measurement through their research (say, the length of the building, but not the height). They also used a photo and proportional reasoning to calculate the missing measure. They measured two dimensions on the photo, one that was known on the actual building and one that was unknown, and they used these measurements and the given actual measurement to calculate the unknown measurement on the actual structure. Students had to use a similar procedure to find the

measurements of smaller features of the structures.

Students also faced challenges when determining angle measures. Some students were unsure about how the angle measures change or how to reproduce the angle measures in their model. These students examined other examples of scale models and drawings to answer their questions and come to the understanding that angle measures remain the same.

Many of the structures included features that were not standard geometric shapes. Students had to determine which of these features to include in their model, and whether to attempt to recreate them as non-standard shapes, or approximate a similar geometric shape to represent them. For example, the National Museum of the American Indian is made up of numerous curved surfaces and spaces. Students who chose this museum struggled with how to represent the curves of the building at a different scale and eventually had to make decisions about how they wanted to represent the structure and the amount of detail to include.

Once the models were completed, the students displayed them for friends and family to view at the school's May Open House night. The models were displayed in the hall as they appear on the National Mall, or in relation to the mall, to help students prepare for the trip. Each model included an information sheet with fun facts about the monument or building, and special features the students should pay attention to when they arrive in DC and see the buildings, memorials, and monuments in person. The class also completed a gallery walk through the scale models and voted on the best model. The model with the greatest number of votes received an award.

Conclusions

This activity provided an opportunity for students to sharpen their real-world problem solving skills while simultaneously engaging in deep mathematics. Students were challenged with messy numbers and measurements or non-existent data, and made decisions about representing non-standard shapes and curves. These types of messy, real-world problems help students develop the habits of mind described in the Standards for Mathematical Practice while addressing required content at a deep level. As an added bonus to this activity, the students' research into the monuments and structures in the nation's capitol added to their excitement and interest in their school trip to Washington, D.C. the following year.

References

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics.* Reston, VA: NCTM.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics.* Washington, D.C.: Authors.

Attachment A: Student Activity Sheet

Washington D.C. Model Algebra Project

In order to help familiarize all 7th graders with Washington, D.C., the 7th grade pre-algebra class is going to build a model of the National Mall and surrounding buildings, memorials, and monuments. Individuals or pairs of students will build three-dimensional models of the buildings, memorials, and monuments. The project will be equivalent to approximately 2 test grades and will be worth **60** points. Two prizes will also be awarded for the best design chosen by everyone in the class. **The structures must be completed by the start of school on _____.** You will also need to turn in a **sketch with measurements of your model by _____** to be approved by the teacher. If your sketch or your structure is late, you will **lose 5 points** for each day that it is late.

Examine the list of structures. You will sign up for a specific structure in the order in which your name is drawn in class. Only one group may sign up for each structure, so be prepared to have one or two back-ups in mind. Signups will be on _____. Be prepared with whom you wish to work (either individually or with one other person) and the structure you would like to model.

You will be turning in 3 things:

1) Your plan for construction including any sketches and all measurements, plus work to show that your measurements are to scale;
2) The model structure (see below for requirements);
3) One-page fact sheet.

Model requirements:

1. The structure must be to scale visually and must be no larger than a rectangular prism with width × length × height dimensions of 24" × 36" × 36" and no smaller than a rectangular prism that is 12" × 12" × 12". (There is one structure that does not have the same dimension restrictions. The Washington Monument can be up to 5 feet in height but its base can be no larger than 18" × 18".)
2. Models must be able to be placed level on a table so the base must be a flat surface.
3. Construction of the models must have a **strong** resemblance to the actual structure so that observers can identify them.
4. Types of construction material are optional but it must be freestanding. All models should be in color even if the color is gray. You will need to supply most of your own materials, although some cardboard and some construction paper will be available from the teacher. Be creative!
5. Monuments and memorials should also include landscape models (e.g. trees, shrubs, water). Buildings are not required to include landscaping but it could increase your creativity bonus points.
6. You are permitted to work in the classroom during homeroom or lunch (or after school if arranged in advance). You will not have class time to work on the model. Your teacher will be available to consult on projects at school or by email.

Fact sheet requirements

1. The fact sheet is due with the structure. It will be posted on the wall next to your structure.
2. It must include: a) color photo of the structure; b) three historical/informational facts; and c) three interesting items students should look for when they visit this structure.

Open House:

There will be an open house to display, among other things, your D.C. models. You are not required to attend but are encouraged to attend to discuss your model with attendees.

Sample Grading Rubric

	Points Earned	Points Possible
Plan with sketch		5
Plan with measurements		5
Plan on time		5
Model meets dimension requirements		5
Model on time		5
Model resembles actual structure		5
Model is freestanding		5
Model is neat and attractive		10
Model is built correctly to scale		5
3 historical facts/3 interesting facts/photo		10
Total points		**60**
Creativity bonus points		
FINAL TOTAL POINTS		**60**

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